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Economic impact of port sectors on South African economy: An input–output analysis

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ABSTRACT

The port sectors in a country play an important role in its economy. This paper presents an input–output analysis on how the port sectors impact a concerned economy using the South African case. Moreover, this paper reports how a rectangular Supply and Use Table system of national accounts can be converted to a traditional square symmetric matrix type system. A range of models, such as demand-driven, supply-driven and price models, were derived for the estimation. From these models, the production effect together with the forward and backward linkage effects, price change effects and employment effects were estimated to determine the impact of port sectors. The overall forward linkage effect of the port sector was 0.97 and the backward one was 0.48, indicating that the port sector does not appear to use other sectors much in producing its activities whereas the port sector is used relatively more by other industries owing to its relatively high forward linkage effect. The overall impact effect of the port sector per unit shortage on all other products was found to be 1.1705. Therefore, one unit shortage in the port sector would have incurred a 17% loss to the entire economy in 2002. Leontief's price model was used for the scenario that what would occur if the price of port sector's cost was increased by various ranges from 5%, 10% and 30% to 50% and 100%.

1. Introduction

The port sectors in a country play an important role in its economy, which is particularly true when a country develops its port as a regional hub. For example, Singapore and Hong Kong have developed their ports as regional hubs in Asia (Lam, 2011), and the Netherlands has developed its ports as a regional hub in Europe. Similarly, Los Angeles and Long Beach function as regional hubs in North America. These ports make utmost efforts in continuously maintaining their ports as hubs and improving them to make them more attractive than competing ports due to their important roles in economic development (Lam and Yap, 2011a, 2011b). Most of these regional hub ports are located in the northern hemisphere. Ports in the southern hemisphere have not reached the status of becoming regional hubs due to relatively underdeveloped economic integration in that region. In recent years, some countries in the southern hemisphere have attempted to develop their ports as regional hubs. On the other hand, the idea of a hub port strategy cannot be justified when people are unsure if this project can bring enough economic benefits to the country. A more problematic case is that people do not understand how port sectors contribute to their economy in terms of the impact of port sectors on other industries, employment effects, price change effects, etc. South Africa is the case of this kind when they considered developing a hub port shifting from a traditional set of gateway port system (Notteboom, 2011). The main container ports in South Africa are Durban, Cape Town and Port Elizabeth, whereas East London and Richards Bay handle small container volumes. The country plans to develop a hub port in a new site, called Ngqura, which is the home town of President Nelson Mandela. Despite this hub development strategy in South Africa, the government and people have wondered how important their port sectors are in their economy in terms of the impact on other industries, employment and price effects. When a country or a region attempts to develop a major port industry, decision-makers should be confident that their new investments will bring sufficient economic impacts on the country and the region in terms of employment effect, value-added amounts, production-inducing effects on other industries, etc. This was the case of South Africa, when the country considered developing a new hub port not only to resolve chronic congestion problem in its representing container

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port, namely Durban, but also to stimulate its economy based on this new hub port. Therefore, the economic impacts had to be analyzed to address these issues.

Surprisingly, despite that there are several studies in the area of port sectors' economic impact analysis available, the extant studies are too narrowly focused on the impact of the sectors (Moon, 1995), merely on employment effect of port sector in regional cases (Hughes, 1997; Musso et al., 2000; Acciaro, 2008), or are focused on broader maritime industries than port sectors (Kwak et al., 2005) or only the shipping sector (Van Der Linden, 2001). One study reported only a descriptive method without a detailed methodology so that replication of the research elsewhere is infeasible (Van Der Linden, 2001). This paper intends to contribute to the literature by presenting an input–output analysis on how the port sectors can affect a concerned economy using the South African case. Musso et al. (2000) proposed a technique to assess the employment impact of the Port of Genoa dealing with several types of ships. But this paper handles more comprehensive economic impacts of port sector in a nation. Moreover, this paper outlines how the rectangular Supply and Use Table system of national accounts can be converted to a traditional square symmetric matrix type system, using the national account data in South Africa. In 1993, South Africa changed their national account system to a Supply and Use Table system recommended by the United Nations (United Nations, 1993). Therefore, this converting approach is differentiated from the previous port impact studies.

The next section explains the methodology and data. Section 3 presents the results and Section 4 discusses the implications and concludes the paper.

2. Methodology and data

The main methodology of this paper is static input–output analysis. There are various methods in assessing economic impact analysis of port sector in the literature. See Acciaro (2008) and Danielis and Gregori (2013) for detailed description of the various methods in the literature. Two major methods in the economic impact analysis are input–output analysis and the computable general equilibrium (CGE) model. The former method is more widely used in the impact analysis of port sector (see Danielis and Gregori, 2013; Kwak et al., 2005; Lee and Yoo, 2014; Morrissey and O'Donoghue, 2013; Van Der Linden, 2001) compared with the latter (see Lee et al., 2011; Lee et al., 2012). DeSalvo (1994) contends that port economic impacts are wrongly estimated as they do not consider the price changes in local area production if there were not any port services available. Therefore, he recommends using a supply-demand model. Recent researches in using the I-O model and CGE model are focused more on the environmental estimation of sectors (Lee et al., 2013; Neuwahl et al., 2008; Su et al., 2013; Su and Ang, 2014). As Acciaro (2008) points out, it is true with input–output analysis that a certain level of subjective classification of disaggregating port sectors from the general industry classification system is needed. However, compared with other methodologies in capturing various inter-linkages between sectors and also production-inducing effect, value-added effect, employment effect, etc. the input–output analysis is more proper to be used for estimating economic impacts and contribution to the South African economy. In addition, using the Supply and Use table, the input–output analysis is the most proper one to capture these effects. The Input–Output (IO) model shows the relationship between the productive sectors of a given economy in a linear, inter-sectoral model. The relationship between the productive sectors and demand can be expressed as follows:

$$X_i = \sum_{j=1}^{N} X_{ij} + F_i = \sum_{j=1}^{N} a_{ij} X_j + F_i \tag{1}$$

or

$$X_j = \sum_{i=1}^{N} X_{ij} + V_j = \sum_{i=1}^{N} r_{ij} X_i + V_j \tag{2}$$

where X_i is the total gross output in sector $i=1,\ldots,N$: a_{ij} are the direct input or technical coefficients that divide X_{ij}, the inter-industry purchases of producing sector i from supply sector j by X_j, which is the total gross output in sector j; r_{ij} are the direct output coefficients that divide X_{ij}, which are the inter-industry purchases of producing sector i, from the supply sector j by X_i, which is the total gross output in sector i; and F_i is the final demand for products in sector i and V_j is the final value-added by sector j. Therefore, Eq. (1) shows the demand-driven model as viewing IO tables vertically, whereas Eq. (2) expresses the supply-driven model as viewing IO tables horizontally.

Eq. (1) can be rewritten in an abbreviated matrix form as $\mathbf{X}=(\mathbf{I}-\mathbf{A})^{-1}\mathbf{F}$ (Chiang, 1984). $\mathbf{I}$ denotes the $N \times N$ identity matrix and $(\mathbf{I}-\mathbf{A})^{-1}$ is called the Leontief inverse matrix. The standard demand-driven model of this matrix form, however, cannot assess the net effects of port sector activities precisely. Hence, the individual port sector needs to be handled as exogenous and placed into the final demand group (Han et al., 2004; Kwak et al., 2005). Therefore, the port sector-based IO model or exogenized IO model for port sector can be expressed as $\mathbf{X}_e=(\mathbf{I}-\mathbf{A}_e)^{-1}(\mathbf{F}_e+\mathbf{A}_m\mathbf{X}_m)$, where subscript e refers to an exogenized matrix and m refers to the port sector. Assuming $\Delta\mathbf{F}_e=0$, results in

$$\Delta\mathbf{X}_e = (\mathbf{I}-\mathbf{A}_e)^{-1}\mathbf{A}_M\Delta\mathbf{X}_M \tag{3}$$

Eq. (3) can be used to estimate the relationship of inter-industries impacted by a change in port investments, i.e. the production inducing effect.

Similarly, the exogenized Leontief's price model can be used for the port price change effect and the exogenized supply driven model can be used for the impact of limited capacity. The models can be explained as follows:

$$\Delta\tilde{\mathbf{P}} = (\mathbf{I}-\mathbf{A}_e')^{-1}\hat{\mathbf{A}}_M\Delta\hat{\mathbf{P}}_M \tag{4}$$

where, $\Delta\tilde{\mathbf{P}}$ is the matrix of normalized price, and $\hat{\mathbf{A}}_M$ is the port sector's matrix treated as exogenous.

The equation shows that the port sector can be treated as exogenous and placed into the primary input group. This is a rewritten form of the conventional Leontief price model without price changes in the value-added sector. If it is assumed that the cost change of each sector can be transferred completely and the annual production of each sector is given, one can assess the effects of a change in wholesale price on the economic system caused by a cost change in the port sector using the following equation (Kwak et al., 2005):

$$\Delta\mathbf{X}_e' = \mathbf{R}_M\Delta\mathbf{X}_M(\mathbf{I}-\mathbf{R}_e)^{-1} \tag{5}$$

where $\mathbf{R}$ is the output coefficient matrix and $(\mathbf{I}-\mathbf{R}_e)^{-1}$ is the output inverse matrix of which elements $ij=\partial X_j/\partial V_i$ represent the total direct and indirect requirements in sector j per unit of final value added in sector i (Han et al., 2004; Kwak et al., 2005). The port sector is also treated as exogenous to disaggregate its impact on other industries. This equation can enable an estimation of the impacts of a unit shortage in the port sector on the output of all other sectors, and can be used as a basis to estimate the macroeconomic impact of the limited capacity.

Up to 1993, South Africa published traditional IO tables. Since 1993, the Supply and Use Tables (SUTs) have been used according to the recommendations of UN 1993 System of National Accounts (SNAs) (United Nations, 1993). The 2002 SUT was used in the present study, as these tables are the most updated and detailed data published by Stat SA during the timing of this research (Statistics South Africa, 2006). The SUT shows how products have been supplied and used by